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OF THE ART OF GREAT ARTILLERY,

Viz.

THE EXPLANATION
of the most excellent and necessary Defi-
nitions, and Questions, pronounced and propoun-
ded, by that rare Souldier and Mathematician, *Thomas*
Digges Esquire; and by him published, in his *Strat-*
iatikos, and *Pantometria*, concerning great
Ordinance, and his Theorems
thereupon.

Together,
VVith certaine Expositions, and an-
swers thereunto adioyned: Written by *Robert*
Norton Gunner.

And by him Dedicated, to the Worshipfull *Iohn*
Reinolds Esquire, Master Gunner
of *England*.

LONDON,

Printed by *Edw: Allde*, for *Iohn Tap*, and are to bee sold at
his Shop, at the corner of Saint
Magnus Church.

1624.

OF THE ART OF GREAT ARTISTRY

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To the Worshipfull *John Reinolds*
Esquire, Master Gunner of England : *Robert*
Norton Gunner, wisheth all health and
happinesse.

Good Sir, (as your sometimes Scholler, &
your now substitute) giue me leaue, to
shew some part of my dutifull thankful-
nesse, for your many louing fauours re-
ceiued; your kinde instructions, your free helping
hand to the beginning of my encouragement, by
your louing Certificate (to the right Honourable the
Lord *Carew* Mr. of his Maiesties Ordinance) of my
sufficiency to performe the place and Office of a
Gunner, for his Maiesties seruice : I therefore haue
presumed to demonstrate a part of my duty herein,
the rather for the louing respect you haue euer
shewed vnto me, and to all others vnder your
Commaund, that endeuour to become seruiceable
for our King, and Countrey, by the diligent pra-
ctise in the excellent Art of great Artillery : It being
my chance of late Sir, to turne ouer *Mr. Digges* his
Bookes, intituled *Stratiaticos*, and *Pantometria*, to
light vpon certaine difcill Definitions, obscure The-
orems, and some subtile questions, concerning the

The Epistle Dedicatorie.

vse of great Ordinance, which as *Mr. Diggs* there
saith, though he long since publikely propounded
them, that none hath yet vndertaken to answere any
one of them: wherefore in his last edition with
short Marginall notes, yes and no, himselfe hath
darkly resolved some of them, as hereafter in the
Margent appeareth, whereof I haue vndertaken to
make a more plaine Exposition of them & the rest,
aswell for mine own, as for others furtherance. And
wheras he hath there coated certaine published Er-
rors in this Science, I haue thought fit to ioyne them
together, with some other Errors that I haue also e-
spied in other Authors writing of this Art: All
which I haue presumed to publish vnder your iudi-
tious Patronage, hoping that my willing pains shal
neither incurre disgrace, nor displease, but rather that
these my first Fruits wil be accepted with such loue
as I truly offer them, whereby I shall be encouraged
(with your good leaue) hereafter to proceed further
with my Treatise of the Art of Artillery, wherein I
perswade my selfe, that the most necessary particu-
lars belonging to the Gunners Art, are more acute-
ly shewed, then in any other Treatise in any Lan-
guage yet extant: And so I shall endeavour to deserue
the continuance of your loue and fauour, and will
rest at his Lordships, and your Worships command,
both whom, I pray God euer to blesse.

Robert Norton.

The Preface.

I commend the Art and Practice of Artillery, it were utterly needlesse, for that it is apparant, that all other Sciences are therein v-sed, as in their conuenient and proper Medium, and grounded on supreme vertue, seeing that without it no Kingdome or Common-weale, can either bee or continue in Peace, or defend it selfe, nor offend their Enemies; it being the powerfull Regent in our Modern Militia: for that it destroyeth Enemies, depresseth Tyrants, chasteneth Rebels, encreaseth Dominions, and is the common-make-peace, and Conseruor of tranquillity in Kingdomes and Common-weales. It consisteth of many ingenious Theoricall and Practicall parts, wherein Knowledge must be the Pylot of Action, or else the action will proue but sillily simple. The Theorick in this (as in all other Sciences) being the fundamentall ground-worke of the practicke part thereof; Therefore Knowing from Doing, must be no more seperated then Letters from Armes: this made the Hebrew, Egiptian, and Persian Souldiers, to be aswell Priests as Gentlemen; and the Grecians to be both Philosophers and Captaines, and the Romaines to be both Souldiers and Schollers; whereby each of them got for their Nation a world of honour. M. Diggs said very well, that it fares in this Art, as in Soldiary, and in

The Preface.

Nauigation; for as many a priuate Souldier, whose braines will only reach how to stand Sentinell, and to March to his Guard, yet takes himselfe to be a perfect Souldier, but if once his wit bee capable to become Corporall of the field, or Sargeant Maior, then he comes to see his former ignorance and wants. Euen so the Common Saylor, if he can but say his Compasse, furl a Sayle, and take turne at Helme and Lead, doth lesse know his ignorance, then such a Master or Pilot as hath sayled a ship by his Chart, Compasse and Art, round the world; And so likewise in this Art, many silly Gunners that neuer sounded the deepe Channell of this Art, will not sticke to say, they know enough, and scorne to learne more, when they God knowes vnderstand not the first principles of good Art or practise; but if by chance, or mischance, they made a good shott once, though without vnderstanding of the true cause of it, it must vphold their reputation for euer, and be sufficient to make Fooles proud. This may chance to be returned me home, yet I care not, for I hope to escape the name of a Coward (though my purse be cudgelled) for that I haue taken vp those weapons, that with a challenge were laid downe so long agoe; But let them that are enuious commend or come mend it, and so I end.

Theirs that loue Art and Practise,

Robert Norton.



Certaine Definitions taken out of
Mr. Digges his Pyrotechnie, and published
in his *Pantometria* concerning Great Or-
dinance. Explained by R. N.
Gunner.

Mr. Digges.

FOR as much as by the hollow Cylinder or Trunke
of the Peece, the violence of all shotte of Great Ar-
tillerie is not onely directed, but also increased, I call
that hollow Cylinder of the Peece, her Soule.

Mr. Norton. This Soule is vsually termed by the
most experienced Gunners, the *Concaue Cylinder*, or
Bore of the Peece: And when she is loaded, so much
thereof as containeth her Charge, is called her *Cham-
ber*, or *Charged Cylinder*, whether she be *Equally Bored*,
or *Camber Bored*; and the rest that is vnfilled, is cal-
led the *vacant Cylinder* of her *Bore*.

M.D. The *Mettaline* substance of the Peece, of what
shape, kinde, or proportion soeuer, I call The Body of the
Peece.

M.N. The seuerall parts of the *Mettallyne* sub-
stance of each Peece, are distinctly knowne to Gun-
ners, by diuers and seuerall Names: As the thickest
of her Mettall at the most eminent ring of her
Brecch.

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Breech is called her *Base-ring* or *Carnooze*, the whole length of her shaft, is called her *Chase*; and those parts of Mettall that *M. Digges* else-where calls her *Eares*, are by *Gunners*, called her *Trunnions*; and before her *Trunnions* that part of her chase towards her *Neck* (which is neere the Mouth) is called her *Coronice*: Her formost extreme of her *Chase*, is called her Mouth or *Muzzle ring*, &c.

M. D. The Soule in all principall Peeces of Battery is euer a perfect vniforme Cylinder comprehended in a Circular Colume, and two equall Circles, whereof the one I call the Head the other the Base.

M. N. The Soule or Concaue ought indeed to be a perfect vniforme Cylinder, except in Chambered Cambered Taper and Belbored Peeces, but by reason of ill and carelesse Foundings, few Peeces come to that perfection; neither doe scant any of their Soules lie exactly in the midst of their Mettals, which (vnlesse for them the *Dispart* and *Dispartline* bee arteficially, and accordingly varied) causeth them to shoot awry, or ouer or vnder, or trauerse.

M. D. The direct line, which by Mathematicall imagination, doth conioyne the Centers of the two Circles, is the perfect and true direction of all Shott made out of great Ordinance, I terme the Axis of that peece Soule.

M. N. Which may very properly bee so called, but it is vsually termed the Axis of her Bore, or the middle line of her Concaue Cylinder, those two Circles at the extremes of that line doth with their planes make right and Orthogonal Angles therewith.

M. D. A

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M.D. *A marke is said to lie within Poynt blanke, when the Peece being directed with her convenient Bullet and Charge, is able to strike and reach that marke.*

M.N. True it is, it hath improperly beene called *Point-blanke*, as farre as any Peece conueyeth her Shott in a right line, neuerthelesse the Peece bee mounted to the third or fourth point; But then if you aske how much that Peece shooteth at *poyn-blanke*, vnlesse you also assigne the Mount, it cannot be certainly answered, And so consequently there is no certaintie of that *point-blanke* for any Peece, because then euery Peece may haue a thousand such seuerall *Point-blanks*. Wherefore I suppose it were more proper to call that only distance *Poynt-blanke*, which the Peece conueyeth her Shott in a right or insenceable crooked line; the *Axis* of her Bore lying leuell with the *Horizon*, that is, she being neither mounted nor embased to any point, or minute of a point, aboue or vnder the Leuell, that being the only *Blanke point*, that is without numeration, as being the beginning, both of eleuation and deprefion.

M. Diggs. *A marke is said to lie within the Mettall of the Peece, being dyrected not by the Axis of the Soule, but by the Coronice and vppermost ring of her Head, and Coyle, is able to reach the Marke.*

M.N. This is by Gunners termed shooting by the Mettall of the Peece, (or *Mira Comune*) whereby it is meant, that the Large line (which is that line which passeth vpon the vppermost of the Peeces Mettall, from the Breech to the Mouth, vertically ouer the *Axis* of the Soule of the Peece) bee directed to the
B marke,

marke, and is able to reach the same.

M.D. The difference of these two Ranges, I call the Difference of the leuell Range of the Soule and Body of the Peece.

M.N. Which by Gunners is called the difference betweene the shooting a Peece by her due dispart, and by the vppermost of her Mettall (or most eminent, the *Base* and *Muzzle-rings*, at her Breech and mouth) and which (vpon the leuell) is neere about twice so much ground, as with a dispart for her Range it is: But this holds not so aboue the leuell, in or neere double, for it only eleuates the peece about five or sixe degrees (in some peeces more, in some lesse) to shoot by the Mettall more then by the dispart increasing vnder the mount of the best randon, but lesse being mounted aboue the same, so much as 4. or 5. or 6. deg. would encrease or decrease the Range for the Eleuations assigned.

M.D. The Axis of the Body of any Peece I terme that strait line, which passeth betweene the Centers of the two outermost Circles at the Coyle and Head of the Peece, which in all Peeces, truly founded, is also the very same with the Axis of the Soule.

M.N. Gunners and Gun-founders call the greatest ring at the Breech (the *Cornooze* or *Base-ring* of the Peece (which *Mr. Diggs* termes the outermost Circle at the Coyle, the other which hee calleth the outermost Circle at the Head, they terme the greatest ring at the Mouth or the *Muzzle-ring*: But that Axis cannot be the very same with the Axis of the *Concave Cylinder*, in peeces that are not truly Founded.

M.D. If the two Axis differ, the Peece is false founded

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founded, and then they are either paralells, or make an Angle: if they be paralells, I terme it the Distance of the Axes of the Body and Soule.

M.N. The definition thereof is very significant and proper, for if in the Casting or Founding of the Peece, the Axis of the Nowell that maketh the hollow Cylinder swarue paralelly aside, it will make the Peece thicker of Mettall all along vpon one side, then it is vpon the opposite side thereof.

M.D. If they be not paralell, their Angles of variation are considered two wayes; That is to say, in *Altitude* and *Latitude*; and those Angles accordingly named the *Anomalie*: Angles of *Altitude* or *Latitude* of those Peeces.

M.N. Those Angles of variation may be three wayes considered, that is, in *Altitude* only, in *Latitude* only, and in *Both* ioyntly, each of which will make the Peece shoote amisse, either ouer and aside, vnder and aside, or directly ouer or vnder the marke; and so for remedy thereof, the Peece must be differently disparted, and accordingly alter her large line vpon the toppe of the Mettall, otherwise then it should haue beene, if her Concaue Cylinder, had lyen directly in the middle of her Mettall.

M.D. The first part of the violent course (of a shotte throwne out of any peece of Ordinance) of Gunners termed *Poynt-blanke reach*, I call the direct line of the Bullets circuit.

M.N. Most vnderstanding Gunners, leaue that improper phrase or Name of *Poynt-blanke*, although it be very ancient (because as I said of the vncertainty therein, for there may be for one Peece 1000. seuerall *poynt-blanks*, if that distance which the Peece conuey-

eth her shott in a straite line, should be *Point-blank*, it carrying so at euery seueral degree or point of mounting, a seuerall distance; namely foure or fīue times so farre vpon the best Randon, as vpon the Leuell: Besides the leuell right Range, might most properly be called the *poyn-blanke* only, because it is the Blanke point, and the beginning of Eleuation and depressi- on: each other point in either, hath its proper deno- mination and Numeration, as the first, second, third, &c. to the twelfth point, which lastly is perpendicu- lar, either aboue or vnder the Horizon: And in place of Point-blanke therefore, they call that distance the straite Line or right Range, proper for the mounting or imbasing assigned.

M. D. The second part being a Curve Circuit, begin- ning at the foresaid declination from the Axis, ascending to the highest Altitude aboue the Horizon, and ending at a like Altitude to his beginning, I terme for distinction sake his Middle Helicall or Conicall Arck.

M. N. Gunners call it the Circuit of the Crooked range or Circular motion of the Shott, or the Mixt or Compound motion thereof; It perticipating of the violent, and the Naturall motions mixt together, beginning at the farther end of the straite Line or Right Range, and ending at the first graze of the Shott, and being peculiarly differing in euery mount or Randon from all the rest; And therefore in two or more seuerall Peeces, each like Randon in the one, is proportionall to the others like Randon: That is, ha- uing both the Randons of one Peece, and one like Randon of another Peece giuen. The rule of pro- portion will produce the Range for the other like

like *Random* for the mounting sought.

M.D. The altitudes of any Bullets Circuit, I call that Line perpendicular, which by imagination Mathematicall, falleth from the Bullet, at his very highest of his Mount, perpendicularly downe to the plaine Horizontall: which line of Altitude, coupled together with the right lines from the Top and Foote, Concurring at the Centre of the Peece Circular Base, doth make a right angled Triangle.

M.N. This and the two next Definitions, although they need no expositions, yet they haue good vses in the Theorems following.

M.D. The Horizontall line of that Triangle I call the Base.

Master Diggs. The other slope Line is the Hypothenusall.

M.D. The Peece direct lyne of that Circuit which is alwayes aboue the Hypothenusall, (for distinction sake) I call the Line Diagonall, For that there are seuerall of these Diagonall lines to all Angles of Random, and together with the Horizontall line doe comprehend the Angle of the Mount.

M.N. In my booke called the Art of Artillery, I terme that Hypothenusall Line, the Secant Range of the Peece, because the same properly representeth as in the Doctrine of right lined Triangles the Secant of the Mount: As the aforesaid perpendicular doth the Tangent, and the Horizontall the Radius thereof; which I so doe, the rather for the more easie and certaine Calculations therein requisite.

M.D. The Peece Horizontall leuell Range, I terme the distance betweene the Peece and the first graze of the Bullet, when the Peece vpon her discharge, lyeth leuell vpon

her Carriage, not mounted upon any lofty plat-forme, but such as lyeth, even with the true Horizontall plane, wher on the Bullet must play.

M.N. This is amongst Gunners most vsually termed the Leuell Range, which I call the Leuel-dead range, and so looke how farre the shott goeth directly, (without any sensible declyning) is vsually called the *Leuell right range*.

M.D. All other Ranges made on any Horizontall plane, by the Bullet, when the Peece is mounted, at any severall Randons, I terme the Horizontall Range.

M.N. They are by Gunners called Randons or Ranges, and by me in the said Booke, termed *Dead-ranges*.

M.D. And because every Peece hath some certaine grade, of the Quadrant whereunto mounted, shee maketh her uttermost Horizontall Range, in such sort, that if yee mount the Peece higher, the Bullet shall flie a shorter distance; and the Horizontall Range returne lesse and lesse againe: That point of the uttermost Randon Horizontall, I terme the Tropicke point or grade.

M.N. Which Range is called by Gunners the best of the Randon, and by mee the greatest dead Range being the furthest distance that the same Peece can possibly conuey her shott: and that hath beene many yeares supposed to be at the mount of 45. degrees (as the meane or middle betweene the Leuell, and 90. degrees) But now it is found to be rather at the mean or middle degree betweene the Leuell and the degree of mounting, that in decreasing, conueyeth the shott iust the distance of the Leuell Range, which is about 82. degrees, so that about 40. degrees above the
Horizon

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Horizon is the best of the Randon if accidents be excepted.

M.D. And that which serues for the discouery of the different violence of all Peeces right Lines or Right Ranges howsoeuer Mounted, (By me called the lines Direct of the Bullets Circuit, and Lynes Dyagonall, I call for destination sake The Theoricke of Lynes Dyagonall.

M.N. For the Theorick, all Dyagonals (or more properly termed *Right Ranges*) for each seuerall degree of mount of the Quadrant from 1.degree to 10. and so for each 10.degrees to 90. I haue thought good to adioyne an abreuiation of one of my Tables

A Table of Right Ranges.

	Gr.	paces.	Gr.	paces.
<i>Leuell</i>	0	192	20	524
	1	209	30	695
	2	227	40	855
	3	244	45	930
	4	261	50	1005
	5	278	60	1140
	6	285	70	1220
	7	302	80	1300
	8	320	90	1350
	9	337		
	10	354		

out of my Booke called the *Arte of Artillery*,

(which hereafter I purpose to publish the vse of the said Table of *Right Ranges*, is thus,

First, if you know the right range of the Peece vpon the Leuell, or vpon any degree mounted, you may thereby (with this Table) know vpon euery other degree of mounting the same Peece, how far she will

conuey her shott in a straite Line, being like loaded, and hauing like accidents. As suppose for example, your Peece vpon the Leuell shoots 250. paces vpon the straite Line; and you desire to know how farre she will shoote in a straite Line being mounted

vnto

vnto 40. degrees about the Horizontall plane; say by the Rule of three: if 192. (the number of the Table for the Leuell) giue 250. your Peece leuell right Range, what shall 855. (the number of this Table for 40. degrees) giue? and you shall finde 1113. (*scilicet*) the fourth proportionall, which is the Number of paces she will conuey her shott, being so mounted to 40. degrees eleuation in the straite Line or right Range sought.

M. D. The other that discovereth the varietie of Ranges of all Peecees, at all degrees of Randon, I call the Theoricke or Scale of Randons.

M. N. For the Theorick of Randons I haue also here epitomized another Table, out of my said Booke of the *Art of Artillery*, whereby, for the sixe first points of the Gunners Quadrant, you hauing the dead or Horizontall Range of one shott made out of any Peece, whether it be of the nature of a *Culuering* (which is betweene 30. and 40. Diametres of her Bore in length by the Range of numbers set against the Letter S.) or whether it be of the quality of a *Cannon* (that is betweene 18. and 24 Diametres of her Bore in length, by the Ranke of Numbers set against the Letter C.) you may hauing one shott by the same, and the rule of Proportion, or rule of 3. knowe her dead or Horizontall Range for any other point of mounting sought. As for example: suppose for a *Culuering* that shooteth leuell 260. paces: I would know how farre she will conuey her shott vpon a Horizontall plane, she being mounted to the third point (that is to 22. gr. $\frac{1}{2}$.) Say as 192. (the number against S.) for the leuell range, in the

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the Table giueth 2032. the number vnder the third point, what will 260. giue worke by the Rule of three, and you shall finde 2752. for the number of paces that she will conuey her shotte upon a Horizontall plane being so mounted.

A Table of Dead or Horizontall ranges.

	0	1	2	3	4	5	6	points.
J.	192	985	1623	2032	2185	2281	2300	paces.
C.	201	958	1600	1983	2135	2232	2250	paces.

M.D. The other Composed of All, and by Conference of all their parts together, framing a Theoricke of perfection, differing in all planes Horizontall, or varying for all kinds of Peeces, and Ballets whatsoeuer; Their Ranges and Randons: The Altitude of their Circuits, together with their Lines Diagonall and Hypothenufall shall be named, The Theoricke of Artillery generall.

M.N. I haue not here runne through all those curious varieties, because they require many experiments, much Art, and large discourse & grounded vpon Mathematicall and practicall demonstration: But, to know how much of the Horizontall Line, lyeth vnder the right Range or straite Line of the shot (being found as before) for the Eleuation giuen, it is thus to be gotten: As the Radius is to the right syne of the Complement of the Eleuation giuen, So is the right Range to the Leuell distance vnder it. And for the Leuell vnder the crooked Range, that is found by subtracting the distance vnder the right Range, out of the whole distance of the Horizontall or dead Range found as aforesaid, and the

C

remainder

remainder shall be the leuell Distance sought. Lastly, for the Circuits of the crooked Ranges, *Mr. Nicholas Tartaglia* in the fourth, fifth, and sixth Propositions of his second Booke of his *Scienza Nova* (which I purpose one day to Translate, if God giue life, and no other man preuent me) doth demonstrate, that the crooked Range of a shott made aboue the Leuell, maketh more then a Quadrant, and vpon the Leuell a iust Quadrant, and vnder the Leuell, lesse then a Quadrant. But for all his subtrill Demonstrations, it is not exactly so found by experience. For it is neither perfectly Circular, elipsicall, parabolicall, Hyperbolicall, nor Conicall, but meerely Helicall, or Helisphericall, according to the proper Leuelling, mounting, or imbasing of the Peece assigned, which let now suffice.

Mr. Digges his
Theoremes, concerning the new Science of great Ordinance, resolving the most part of his *Artillery Questions* in Stratiaticos or proposed.

The first Theoreme.

THere are three chiefe most materiall and efficient causes of the greater violence of any shotte made out of great Ordinance, viz. the Powder, the Peece, and the waight of the Bullet.

The

The 2. Theoreme.

Powder is compounded of three Principles or Elements, *Saltpetre*, *Sulphur*, and *Cole*, whereof *Saltpetre* is it that giues the chiefest violence.

The 3. Theoreme.

Albeit *Saltpetre* be indeed the onely or most materiall cause of the violence, And that Powder commonly found most forcible, that is richest of *Petre*, yet is there a certaine proportion of Perfection of these three Components. And that in such sort, as if you adde more or lesse *Petre*, the violence shall abate.

The 4. Theoreme.

Although Powder be also the most efficient cause of the force and violence of any shotte, yet is there such a proportionall charge of Powder to be found for euery seuerall Peece, in regard of the proportion of her charged and vacant *Cylinders*, as giuing more or lesse, then the same proportionall charges, it shall diminish, and not increase the violence of the shotte.

The 5. Theoreme.

If any two Bullets of equall quantitie, but vnequall waight, be let fall from any lostie place to the Horizon, the more waightie shall euer fall the more swiftly : albeit not proportionally to their waight; which Axiome is indeed erroneous, albeit a great Philosopher hath auerred the same.

The 6. Theoreme.

If two equall Bullets of different waight, be shot out of one and the same Peece directly to the Zenith, both Bullets being of massie mettall, and charged with one quantity and kinde of Powder, the lighter

shall alwayes outflie the heauier. But such kinde of Bullets they may be charged with all, as the Heauier shall outflie the Lighter, although they be both discharged with the same Peece, and quantitie of the same Powder.

The 7. Theoreme.

There is such a conuenient waight to be found of the *Bullet*, in respect of the *Powder* and *Peece*, as the Bullets mettall being either heauier or lighter then that waight, shall rather hinder then further the violence or farre range of the shot.

The 8. Theoreme.

There is such a conuenient Proportion to be found of the length of euery *Peece* to his *Bore* or Bullets Diameter in respect of the *Powder*, and waight of the Ball, as either encreasing or diminishing that proportion it shall abate also, and hinder the violence of the shotte.

The 9. Theoreme.

This proportion exactly found in any one *Peece*, doth not hold in all other, and yet the difference and alteration such, as may bee reduced to Rules certaine.

The 10. Theoreme.

Besides these three most materiall causes of violence, the Randons also and different Mounts of *Peeces*, cause a great alteration, not onely of the farre shooting of all *Peeces*, but also of their violent *Batterie*. And albeit the different alterations are very intricate and strange, yet haue they a *Theoricke* certaine.

The 11. Theoreme.

There are also many other Accidentall alterations happening by reason of the winde, the thicknesse or thinnesse of the Ayre, the heating or cooling of the Peece, the different manner of charging by Ramming fast or loose the Powder, by close or loose rouling or lying of the Bullet, by the vnequall recule of the Peece, either by reason of the vnequality of the Platforme or Wheelles, or by the vneuen lying of the Peece in his Carriage or deformitie of the Axtree, with diners other such like, whereof no rules certaine can be prescribed, to reduce these vncertaine differences to any certaine proportions: but all these are by Practise, Discretion, and Iudgement to bee considered, and vniformely guided and performed in their best perfection.

The 12. Theoreme.

Any Peece mounted 90. grades above the Horizon, throweth his Bullet most violently immediatly after the discharge, and then the motion groweth slower, till the Bullet bee come to his vtmost Altitude, and then by Perpendicular falling, encreaseth by little and little, his swiftnesse againe, euen till it come to the Horizon. But at all other Randons, it falleth not so out.

The 13. Theoreme.

Albeit in the subtiltie of Geometricall Demonstration, no part of the Bullets violent motion, can bee truely auerred a right or direct line, saue onely the Perpendicular: yet in these experiments *Mechanicall*, That first part of the violent motion (I meane so farre as the Peece is said to carry *Point-Blanke*) being so

neere the direct, is, and may well be termed the direct line. As all water levels are accounted in all Mechanicall operations, the Perfectest levels and directest lines. Albeit the subtiltie of Geometricall Demonstration, doth finde them not right or direct, but Curve or Circular.

The 14. Theoreme.

When any Peece is mounted directly to the Zenith. Then doth his Motion violent (being in that scituation directly opposite to the naturall) carry the *Bullet* in a perfect right line, directly vpward, till the force of the violence be spent, and the Naturall motion haue gotten the victorie. And then doth the Naturall returne the *Bullet* downward againe, by the very same Perpendicular line. And so is the whole motion of the *Bullet* in this case a very direct Perpendicular to the Horizon.

The 15. Theoreme.

But if any Peece be discharged vpon any Angle of Randon, albeit the violent motion contend to carry the *Bullet* directly by the line Diagonall; Yet the Perpendicular motion being not directly opposite, doth though vnsensibly, euen from the beginning by little and little drawe it from that direct and Diagonall course. And as the violent doth decay, so doth the naturall encrease: and of these two right lined motions, is made that mixt Curve Helicall Circuit of the *Bullet*.

The 16. Theoreme.

Any Peece therefore discharged at any Mount or Randon, first throweth forth her *Bullet* directly a certaine distance, called of Gunners their *Point-Blanke Range*,

Range, and then it maketh a Curve declining Arke, and after finisheth either in a direct line, or nigh inclining towards it.

The 17. Theoreme.

The further that any Peece shooteth in her direct line, commonly called *Point-Blanke*, the deeper also she pierceth in her Battery, if the Bullet bee not of substance bricke or frangeable.

The 18. Theoreme.

The more ponderous a *Bullet* is, the more it shaketh in Battery, albeit it pierce not alwayes so deepe as the lighter or lesser shotte conveniently charged.

The 19. Theoreme.

Any two Peeces of Battery Ordinance, charged with one kinde of Bullet, and shott into one Rampire of massie vniforme kinde of Substance, shall euer make their Profundities of pearcing Proportionall to their leuell Ranges Horizontall, if they bee discharged either leuel or at one grade of Randon, and at like distance.

The 20. Theoreme.

Any two Peeces of Batterie discharged into any Rampire of vniforme massie substance, shall euer make their Pearcing depths proportionall to their lines Diagonall, albeit these Peeces bee discharged from different Randons, so as they batter at like distance.

The 21. Theoreme.

As *Archimides* line Helicall or Spirall, is made by the direct motion of a point carried in a right line, while that right line is Circularly turned as Semidiameter vpon his Circles Center; So is this Artillery
Helicall

Helicall line of the Bullets Circuit created onely by two right lined motions becomming more or lesse *Curve* according to the difference of their Angles, occasioned by the severall Angles of Randon. Whereupon by demonstration Geometricall, a *Theoricke* may be framed, that shall deliuer a true and perfect description of those *Helicall* lines at all Angles made betweene the Horizon and the Peecces lines Diagonall.

The 22. Theoreme.

These direct or Diagonall lines, are alwayes longest when the Peecces Axis is directed to the Zenith. And alwayes as the Peecces Axis declineth more and more to the Horizon. So doe the Diagonall lines grow shorter, and at the leuell Horizontall, shortest of all.

The 23. Theoreme.

These direct lines Diagonall, albeit they encrease in length at euery grade of Randon from the Horizon to the Zenith, yet is not their encrease vniforme or proportionall, either to their degrees of Randon or Horizontall Ranges, nor yet to their Circuits or Altitudes, and yet such as may be reduced to a *Theorike* certaine.

The 24. Theoreme.

The middle *Curve* Arkes of the Bullets Circuits, compound of the violent and naturall motions of the Bullet, albeit they be indeed meere Helicall, yet haue they a very great resemblance of the Arks Conicall. And in Randons aboue 45. they do much resemble the Hyperbole, and in all vnder the *Elleipsis*: But exactly they neuer accord, being indeed *spirall* mixt and *Helicall*.

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The 25. Theoreme.

Any Peece discharged at any one Randon with like Bullets, and severall charges of Powder, shall make both their lines Diagonall and Curve Circuits of different longitude, but the Curve Arkes shall alwaies be as Paralels, and their Longitudes Proportionall to their lines Diagonall.

The 26. Theoreme.

The last declining line of the *Bullet's* Circuit, albe it it seemes to approach somewhat to the nature of a direct line againe, yet is it indeed still *Helicall* and mixt, so long as there remaineth any part of the motion violent. But after that is cleane spent, the rest of his course to the Horizon is direct and Perpendicular, and a perfect right line indeed, which is best discerned in those Grades of Randon, which are betweene the Zenith and the Mount or Randon *Æquorizontall*.

The 27. Theoreme.

This declining line doth alwayes make a greater and greater Angle with the Horizon, as you raise the Peece to a greater Mount, till you come to the Mount *Equorizantall*, about which Point the same declining line becommeth Perpendicular before the *Bullet* fall to the Horizon.

The 28. Theoreme.

The Horizontall Ranges in all Peecces mounted from the Horizon toward the Zenith, doth not still encrease, but at euery grade of Randon are longer, till you come to the Point or mount *Tropicall*, commonly called the vtmost Randon, which hath bin generally thought to be the grade 45. but is not so. And

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from

from that *Tropicall* grade vpward, the Ranges decrease againe till you come to the grade *Æquorizontall*, so called because the *Bullet* then falleth a like distance to the leuell Ranges.

The 29. Theoreme.

This *Æquorizontall* Grade is as far distant from the Zenith, as that Grade is from the Horizon, which shall cause the Peece to shoot in the *Horizontall* plaine a distance equall to his highest Altitude or longest line *Diagonall*.

The 30. Theoreme.

The Mounting of any Peece aboue his *Æquorizontall* grade doth still decrease her *Horizontall* Ranges euen till it come to the Zenith. But in a Proportion different from any of the former, her *Bullet* ending euery of those Circuits in a direct line *Perpendicular*.

The 31. Theoreme.

The Gradual encrease and decrease of these Ranges *Horizontall*, albeit they are equall in the *Quadrant*, yet are they neither equall nor proportionall in the Horizon, neither the Ranges nor their *Internalls*. Neither compared between themselves, nor yet conferred with the Chords or Sines of their Arks. And yet is there such a kinde of Proportionall encrease and decrease of the proportion of their *Internalls*, as may be reduced to a *Theorike* certaine.

The 32. Theoreme.

The *Tropicall* grade commonly called the vtmost Randon, is not as hath beene generally supposed the Medium or Middle betweene the Horizon and the Zenith, *Viz.* 45. but rather betweene the Horizon
and

and the grade *Æquorizontall*, which will fall out much higher 50. from the Zenith, and 40. from the Horizon.

The 33. Theoreme.

The highest *Altitude* of any *Bullets* Circuit is farthest distant from the Peece, when she is discharged at her utmost Randon or point *Tropicall*, and at all other Randons either above or beneath that *Tropicall Point*: That highest *Altitude* is euer least distant, and the bases of these Triangles doe euer encrease to the Randon *Tropicall*, and decrease after, euen as the *Horizontall* Ranges; but in Proportion more different euery one from other.

The 34. Theoreme.

The *Altitudes* of the Circuits of Randons doe not encrease and decrease as their Ranges *Reciprocally*, but from the Horizon in euery grade to the Zenith, doe still encrease, but yet neither equally nor Proportionally, neither conferred betweene themselves, neither yet with sines or Chordes of their Arkes of Randon. And yet the encrease and decrease of their Interualls Proportions, such as may be reduced to a *Theorike* certaine.

The 35. Theoreme.

The *Hypothenusall* lines of all these different Circuits carry a mixt proportion of the composition of the Proportions of these *Altitudes* and bases by addition of their Squares, But are not proportionall to the lines Diagonall of their corresponding Angles of Randon.

The 36. Theoreme.

Any two Peeces of Ordinance being mounted to

any one Grade of Randon shall make their Horizontall Ranges of their Bullets Proportionall to the *Altitudes* of their Circuits.

The 37. Theoreme.

The Ranges Horizontall of any two Peeces discharged at one Randon, will be alway proportionall to their lines Diagonall of the same Peeces Circuits.

The 38. Theoreme.

The Horizontall leuell Ranges of any two Peeces of Artillery are euer proportionall to the vtmost Ranges Horizontall of the same Peeces.

The 39. Theoreme.

Any two Peeces whatsoeuer discharged at one Randon, doe euer make their lines Diagonall, and lines of Altitude Proportionall howsoeuer the Proportions of their charges vary.

The 40. Theoreme.

Any two Peeces whatsoeuer discharged at one grade of Randon vpon any enclining or declining Plaine shall neuerthelesse make their Ranges proportionall to their lines Diagonall and Altitudes of those their different Ranges. Albeit the Peeces be charged with a different kinde of proportion of Powder and Bullet, so as the shot be made in a faire Calme day, as is in these cases alwayes presupposed, becaute for such vncertaine Accidents there cannot certaine Rules Artificiall be prescribed.

The 41. Theoreme.

One Peece discharged at seuerall Randons vnder the vtmost Randon, being a like charged and discharged, and the Peece also of one temper, at both times,

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times, shall euer make seuerall Ranges. But if she be discharged at seuerall Randons, the one aboue the *Tropicke* point, the other vnder, Then may their Ranges be equall notwithstanding their Randons, *Lines Diagonall, Altitudes, Bases, and Lines Hypothemusall*, be all different.

The 42. Theoreme.

When any Peece (being twice discharged at seuerall Randons, the one aboue, the other beneath the *Tropicke* point) shall make the same or equall Ranges in a *Horizontall* plaine. The middle grade betweene those seuerall Mounts is very nigh the grade of vtmost Randon: and the Peece Mounted to that middle grade, shall then make very nigh his vtmost *Horizontall* Range.

The 43. Theoreme.

The grade of vtmost Randon or point *Tropicall* of any Peece in a Plaine *Horizontall*, shall not be the *Tropicall* grade of that Peece, in a plaine declining or inclining, but an other Peculiar to that Angle of Inclination or Declination.

The 44. Theoreme.

Any Peece discharged at his grade of vtmost advantage *Horizontall* vpon a Plaine inclining, shall not make so great a Range as on his plaine *Horizontall*: But contrariwise on a Plaine discending shall make a farther Range.

The 45. Theoreme.

A Peece discharged first at his due leuell, and againe at his *Aequorizontall* grade, albeit in the plaine *Horizontall* they make equall Ranges, yet in Plaines declining shall they not so doe, but alwaies the

Leuell Ranges shall euer out-shoot in all declining Plaines the Range of that grade *Æquorizontall*.

The 46. Theoreme.

A Peece discharged at any grade from the Zenith to the grade *Æquorizontall*, shall alwaies make a greater Range in any Plaine enclining or declining, then on the Plaine *Horizontall*.

The 47. Theoreme.

In all plaines enclining at all Randons betweene the *Horizontall* Leuell and point *Tropicall*, all Peecees shoote farther in their Plaines *Horizontall*, then on any Plaines enclining, and contrarywise in Plaines Declining: But about the *Tropike* grade not alwayes so, but sometimes, and not alwaies contrary.

The 48. Theoreme.

In any Plaine whether it be enclining or declining, if any Peece of Ordinance be discharged being *Paralell* or Equidistant to that plaine, and the first graze or bound noted. If the same Peece bee with like charge vniformely charged and discharged at such an high grade of Randon as may cause the *Bullet* Range the former Distance : That middle grade of the Quadrant, which lyeth betweene these two Mounts, shall be very nigh the grade of vtmost aduantage, for that enclining or declining plaine. The which in all plaines enclining, will be about the vtmost Range *Horizontall*, and in all declining vnder.

The 49. Theoreme.

In all enclining or declining playnes, as the grade *Tropike* of greatest aduantage doth varie ; So doth also the proportions of their Ranges, at euery grade of Randon differ, whether they be accounted from
the

the Zenith, Horizon or Playnes, enclining or declining. But yet in such an assured and certaine manner as may be reduced to a *Theoricke* perfect.

The 50. Theoreme.

In all Grades of Randons, and in all manner of Peeces, whether the playnes be *Horizontall* or vary by Inclination or Declination, the *Diagonall* Lines are still proportionall to those of the plaines *Horizontall* respectiuey taken by Graduation from the Zenith, in all Peeces whatsoeuer. But the Lines of *Altitudes*, their *Bases* and Lines *Hipothensall* are euer different in euery seuerall Angle, both of Inclination and declination, and vary by such a different Proportion from the *Horizontall*, as they are to be discovered by a seuerall Methode of Calculation.

The 51. Theoreme.

Such *Theorikes*, *Scates*, and *Instruments*, may be framed for the Inuention of these strange Proportions of *Altitudes*, *Lines Diagonall*, and *Ranges Horizontall*, as thereby with the ayde of *Calculations Arithmeticall*, and some Rules *Geometricall*, a man may exactly and readily discover the true Circuits and Ranges of the *Bullets* of all Peeces of Ordinance whatsoeuer, mounted howsoeuer; and vpon all grounds or plaines enclining or declining, that can be Imagined, as shortly to the world by Gods grace shall bee made apparant.

Mr. Digges

Mr. Digges his
Questions, in the Art of Artillery
 with *Mr. Nortons* Answers to them as
 followeth.

Of Powder.

I.

Mr. Digge:.

V *Hether there be not for any Peece proponed
 such a certaine quantity of Powder to be found,
 as duly to the charge of the same Peece agreeth,
 And that in such sort, that Charging the Peece with more
 or lesse then that quantitie, it shall binder the farre ran-
 ging of the Bullet.*

Mr. N. By the fourth Theoreme aforesaid, There
 is such a certaine proportionall charge of powder
 to be found for euery Peece, in regard of her Char-
 ged and vacant Cylinder: But there must further be a
 consideration had concerning waight of the Shott,
 the Fortification of the Peece, & the different force of
 the sorts of powder, each to be proportionall to o-
 ther, and so three *Dyametres* of the Bore, or $\frac{2}{3}$. of the
 waight of her Shott in Corne powder for *Cannons*.
 Or $\frac{2}{3}$. of the *Dyametres*, or $\frac{1}{4}$. of the waight of the Iron
 Shot of Corned (Artillery) powder, for the *Culuerings*.
 And foure *Dyametres*, or the whole waight of the
 Shott of such powder for Sakers, Falcons, and les-
 ser Ordinance, is vsually accompted as their due pro-
 portionall Charges, which charge (if it could bee
 readily

readily found) would be iust so much powder, as being all fired within the *Cylinder*, will at that instant haue carryed the shotte iust to the mouth of the Peece.

2.

M. D. *whether one and the selfe-same Peece twice charged with one and the selfesame quantity of Powder and Bullet, discharged also at the same Randon, shall make the same Ranges?*

M. N. No, for at the Second time it will shoote further then at the first: As well because the Ayre that before was still quiet and vnbroken, will be then moued that way the shotte goeth, and by the course of the shotte become broken. And also for that the charged *Cylinder* will then be dryer and warmer then at the first, and cause the Powder to fire quicker, and better together, which will adde more force thereunto.

3.

M. D. *If a Peece be discharged with the waight of his Bullet in Serpentine powder, and afterwards discharged with halfe the waight of his Bullet in such Corne powder as shall cause the Peece to cast the same ground; I demand if the same Peece be againe Charged with halfe the quantity of either sort, whether these Ranges shall also bee equall? The forme of Charging being vniforme, and temper of the Peece alike.*

No.

M. N. No, for the last halfe will one of them be then more farther off from due proportionall Charge of the said Peece, then the other was from his Mate at the first; And therefore it is certaine, that the last halfe of the *Corne Powder*, will shoote

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much

much further then the halfe of the *Serpentine Powder* can doe, because there is more *Petre* in the quantity of the last halfe, then in so much of the first halfe of the *Corne Powder*, and lesse in the other.

4.

No. M. D. If two Peeces of the same Length and Bullet be charged with one kinde of Powder, but severall waights; I demand whether the Ranges shall be proportionall to the said waights, Or to the Square, Cube, or Squared Square rootes of the said waights: Or whether the Proportion of the Ranges, be not to be found, without any further respect, either to the length of the Peece, or Ponderositie of the Bullet? Considering (by Hypothesis) all those are equall.

M. N. Their Ranges will not bee proportionall to those Roots, (besides, whether they should be alike or differently mounted, being not here expressed. Neither the different waights of the Powder) therefore without them, those nor any other proportion certaine can hold; yet they may be found in a Compounded proportion, hauing respect vnto the proportions betweene the force of the Powder, waight of the Shott, and length of the Peece.

5.

No. M. D. whether the Proportion found in one kinde of Powder, hold not in all other kindes; of what mixture soeuer it be, the Peeces and Bullets (being as is before supposed) equall?

M. N. No, for the proportions of all different kindes of Powder, equall in waight or Measure, doe differ in Force accordingly more or lesse, as there is more or lesse *Petre*, and working therein; Neuerthe-
lesse

lesse the equality of the rest, for that a lesser waight or measure of stronger Powder will equall the proportionall Force of a greater waight or measure of weaker Powder, and these are for Action in Geometricall proportion augmented, but for Resistance they are augmented in Arithmetically proportion, as an excellent Philosopher elsewhere doth largely Demonstrate.

6.

M. D. *whether the proportion of such Ranges, be not* He referreth this to a Booke neuer yet extant.
a Meane proportionall resulting of the Commixion of the equality of the Peece lengths and Bullets; and the inequality of the Powders Quantity? The Quality being supposed alike.

M. N. I say it cometh so neere to such a mean proportionality, as that in practise it might be accepted for the same indeed; But it not being exactly so, and also not being easily found, by reason it lurketh vnder so many compounded varieties and contrarities, we must content ourselues with such a necessary Neereneffe, as in my Exposition of *M. Digges* his Definitions are exemplified, or to be shewed elsewhere more largely.

Of the length of the Peece and Powder.

7.

Mr. Digges. *whether two Peecees being in all respects equall, saving only in length, being charged with one Bullet, and one quantity of Powder shall not make equall Grazes?*

Yes.

E 2

M. Norton.

M.N. No, for both by *Master Digges* his answer and mine to the first Question, there is a Charge certaine; which is, that two Peeces of severall lengths, and otherwise equall, cannot with one Quantity of like Powder, haue both of them such a Charge, as can possibly be equally or proportionally neereft to their Charge certaine; And therefore their severall *Grazes* must needs be also different.

8.

Not alwaies. *M.D.* whether the longer Cannon shall make the greater Range, whatsoever Quantity, or kinde of Powder they be discharged withall, the Quantity of Powder being equall?

M.N. I imagine that *Master Digges* meant the Quality or Kinde of Powder, which may cause proportionall difference, according to their severall Forces: Otherwise I may answer yes, vnlesse the longer Peeces charge be as much ouer, as the shorter is vnder, the Charges duely certaine.

9.

Yes, but not without respect of the Powder.

M.D. whether there be not a certaine convenient Length of the Peece, in respect of his Bore or Bullet, to make the utmost Range, in such sort, that making the Cannon longer, shall rather hinder then further.

M.N. Surely *Master Digges* meant herein as in the last, the length of the Cylinder or Chace, by name of making the Cannon longer, & then the question is by him truly answered yes. If the proportional Force and Quantity of the Powder be therein also considered and excepted; as I haue vnder his former Definitions exemplified.

M.D.

10.

M.D. *whether this Length and proportion being found in one Peece, hold in all other (the proportion I meane for the Length) must of necessity alter?*

No.

M.N. One proportion cannot hold for *Cannons* and *Minions* of (not above 24. Dyametres) and also for *Culverings* and *Sakers* (not lesse then 30. Dyametres of their Bores in Length) and the greater waight of the greater Shott, resisting the powders Force so much the more, by how much the more the *Peece* is mounted, and doth likewise in his Course more (by the greater grauity thereof) affect to descend out of the strait Line of her Course, then the lighter doth, though both beginning with equall swiftnesse, each of these and all, or some of them together doe hinder generall proportions, besides the lesse proportion of fortifying of the *Cannon*, (which Mettall) then of the *Culvering*, and yet the proportion of the shott more increasing in the Cube, causeth that the *Cannon* can neither burne within her, nor endure $\frac{1}{4}$. in Corne powder of the waight of her shott, as the *Culvering* can doe, much lesse as the *Falcon*, *Saker*, &c. which can endure to burne within them, their shotts whole waight in such powder, therefore they must needs convey the shott a greater proportionall distance, then the *Cannon* or *Minion* can possibly doe, and consequently breake the proportion above in his question mentioned.

11.

M.D. *The proportion being by Experience found with Vnanswered, Serpentine Powder according to the ordinary Charge;*

E 3

whether

Unanswered. *whether giuing like quantity of Corne Powder the same Proportion of Perfection shall hold, or a new bee sought, in respect of the alteration of the Powder?*

M. N. No, that perfect proportion will bee altered and anew to be sought, for there will a different quantity of *Petre* be found in the like quantity of those seuerall powders; wherefore their Forces, and consequently the *Ranges* must needs also differ. And further you may vnderstand, that although *Serpentyne powder* be growne out of vse (because *Corne powder* is found better for Ordinance) and that the Force thereof was commonly accepted in compared proportion to *Corne Powder*, as $\frac{1}{2}$. to 1. Yet for that there is also in seuerall sorts or Receipts of *Corne powder* greater differences of Force found betweene them: Therefore also the said proportion cannot hold, for if in one pound of *Corne powder* of the receipt of 6. 1. and 1. there bee 12. ounces of *Petre*, whereas in one pound of *Powder* of the receipt of 4. 1. and 1. there will be but 10. ounces and $\frac{2}{3}$. of *petre* found; You may thereby also know what quantity of any one sort or receipt of *Powder* will be of equall Force, with any assigned quantity of any other sort of powder, whose receipt or mixture you already know, or can finde out, which you may easily doe many wayes; As in my Booke of the *Art of Artillery* at large is shewed.

12.

M. D. *If two Peeces being in all respects equall, saue only in Length, bee discharged with one Bullet, and Quantity of one sort of Powder, make seuerall Ranges (at Poynt blanke discharged) I demaund whether the same*

same proportion of Ranges shall still continue, with whatsoever Quantity or kinde of Powder the same Peeces be Charged? The Quantity being alwayes equall, and all other Circumstances in Charging and Discharging in either of them alike?

No.

M.N. The proportions cannot continue the same; For if in the former two shots the assigned Charge be as much over for the shortest Peece, as it is vnder for the Longest, or in any other proportion, it cannot be in like proportion in the Latter two shots.

M.D. If two Peeces in all respects alike, save only in length, be charged with one Bullet, in Ordinary Serpentine-Powder, I demaund whether their Ranges shall beare the proportion of the length of their Cannons, or of the Vacant-hollow-Cannons, from the Charge to the Mouth? Or if it beare not the same proportion, whether they carry not the proportion of the Square, Cube, or Squared-Square Rootes? Considering all other Circumstances, all other things being equall saving only the Cannons? it is apparant, that from their Proportion, as the Originall cause, the proportion of Ranges must in this case be derived.

No.

M.N. We must conceiue that which Mr. Digges here and elsewhere termeth the Peeces Cannons, is the Vacant and Charged or Concave Cylinder of the Peece, in her whole length within, or the Chase without. And to the first part of this double Question, I Answer, that the assigned Charge must needs be neerer to her most due Charge certaine for one of the Peeces then for the other. And for the latter part

I

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I answer No, as vnto the fourth Question: But to the Conclusion I answer, as I did to the first Question, that from proportionallity of the quantity and force of the Charge, with the length of the Peece, and height and waight of the shott, the Proportion of Ranges for each seuerall Mounting is deriued.

14.

No. M. D. *If there bee three Peeces in all respects equall, sauing in length of their Cannons or Cylinders, and yet those three longitudes proportionall: I demaund whether the Ranges of their Bullets shall not be proportionall? All other Circumstances saue only this of Lengths being one, equall, and alike.*

M. N. The longest will outrange the two shorter, if that Peece be so well sortefied, that she can endure her due charge of powder, and so by the same reason the middlemost may outrange the shortest; And yet their lengths may shorten in such sort, that their Ranges vpon any like Mounting, or vpon the Leuell, may be proportionalls, but then the seuerall lengths of their Chases will not bee proportionall thereto: For that one, or those two which are neereft the due charge of Powder, shall carry the shott with more aduantage, then the more or most remote from their due charge, in regard of that which their lengths and waight of the shott can doe.

15.

Unanswered. M. D. *If three Peeces as afore, hauing the Longitude of their hollow or vacant Cylinders proportionall, whether, then (all the rest being equall and vniforme,) the Ranges shall not be proportionalls?*

M. N.

M.N. I say no : If their Bore bee equall, their Charge equall, and yet their Lengthes shortening or lengthening by Proportion, because the Charge will only in one of them come neereſt vnto the due charge, which aduantage will breake the proportion of it, with the other two; But if the middlemoſt for length were the neereſt vnto the certaine length due to the aſſigned charge of Powder, then the longeſt muſt needs be too long, and the ſhorteſt too ſhort, which diſaduantages would come neerer to proportionality, but not be exactly ſo; for diuers cauſes elſewhere herein ſhewed.

16.

M.D. Or if in one of theſe Caſes the proportion of the Ranges be not a Meane Proportionall, reſulting of the commixion of the Equallity of the Bullets waights, the Equallity of the Powder, and the Inequallity of the Longitudes of the Cylinders, either whole or vacant?

Vnanswered.

M.N. Yes, it is doubtleſſe a meane reſulting proportionall of the Commixion of the equalities, with the inequallity, but alwaies with the former Cautions mentioned in the two laſt precedent Answers.

Of the Powder & length of the Peece conſidered with the Bullet.

17.

M.D. If a Peece twice charged with one quantity of the ſame Powder, but the Bullets in waight different, I demaund whether the lighter ſhall alway outfly the heavier, or that ſome conuenient waight may be found?

Note there is a meane conuenient.

F

M.N.

M.N. Doubtlesse there is a meane conuenient waight may be found, which must be proportionall to the Force that moueth it; For a mans hand can throw a waight of 4. pound of Lead further then a waight of 20. pound of Iron, or then 2. pound of Feathers. And so shooting seuerally in a *Saker* three shotts, one of Lead, another of Iron, and the third of Stone with 12. pound of powder (as the Leaden shott would weigh) then will the Shotte of Lead outrange the other two, and that of Iron will outrange that of Stone; But seuerally shooting those three with 8. pound of powder, as the Iron shotte weigheth: it will outrange the Lead shott, and the Lead the Stone shott: But shooting them againe seuerally with 4. pound of powder, then will the Stone shott outrange the Iron, and the Iron the Lead. Besides, the more a Peece is mounted, the more doth the heavier waight of the shotte resist the Mouer, which if it be too much or too little for the Force, it then impairerh the Motion; Therefore will the conuenient meane waight be proportionall.

18.

Yes

M.D. whether this conuenient waight of the Bullee alter not, according to the Quantity or Validity of the Powder?

M.N. Yes, for the Leaden shott will require the whole waight of ordinary powder, or $\frac{1}{4}$. of the *Corne powder*; And the Iron shott $\frac{1}{4}$. of ordinary, or $\frac{1}{3}$. of the best; And the stone $\frac{1}{3}$. of the ordinary, or $\frac{1}{2}$. of the best powder, As hath beene ordinarily obserued to doe generally his best execution; But this holds not alwaies for the force of powder and other
 propor-

proportions and accidents are continually variable.

19.

M. D. *whether to finde the said conuenient Ponderositie of the Bullet, it be sufficient to consider the Powder, or that the Longitude of the Peece also cause therein a diuersitie?*

Both.

M. N. Yes, the longer Peece will require the more powder to be fired within her, before the shot can ariue to the iust mouth of the Peece to be then discharged out, then the shorter will, For if all the powder be fired before the shot ariue at the mouth, the after-running thereof within the rest of the Cylinder will hinder the swiftnesse thereof, by the Cylinders being too long. And likewise if the shot be discharged out of the Peeces mouth before all the powder be fired, and that it haue receiued all the force of the Powder for want of sufficient length in the Cylinder of the Peece, it will be also hindered. Therefore there is a conuenient length for the conuenient waight to accompany with it continually proportionall.

20.

M. D. *If two Peeces be twice charged, first with an Iron, then with a Lead shot; The Quantities of Powder, at both times equall: Whether the differences of the Ranges be not deriued only from the proportions of the Waights of these Bullets? (All other circumstances by proportion differing not) And what relation to the Ponderosity of the Bullets these Ranges haue?*

Vnanswered.

M. N. To this I haue already sufficiently Answered, especially in the three last precedent Answers, For as much as herein the proper waight of the Shot, & due length of the Peece, proportionall to the

F 2

Force

Force of the Powder and Height of the Bore, doe all domineere in altering their Shotts Ranges. And besides we seldome vse Leade shott, but often Stone shott in great Ordinance, wherefore the Questions and Answers may bee better applied to Iron and Stone, then to Iron and Lead.

21.

Vnanswered.

M.D. Two Peecces being in all respects equall, and charged with one kinde of Powder, but different Bullets, the one Iron, the other Lead; And either hauing the waight of his Bullet: I demaund whether the ranges be equall?

M.N. No, but proportionall according as the length of the Peece is neereft proportion as aforesaid.

22.

No.

M.D. If one Peece bee charged three severall times, first with a Stone Bullet, then with Iron, and finally with Lead: And the Iron of such temper, that it bee an exact meane proportionall in waight betweene the other two, being all discharged with one quantity of Powder, I demaund whether the Ranges shall bee in continuall proportion?

M.N. No, for the length of the Peece; Height of the Bore, and force of the Powder; will be neerer the conuenient meane, for one of the said shotts, then for any of the other two: Therefore the continued proportion will not hold herein.

23.

No.

M.D. whether a Peece being twice charged, first with Iron, then with Lead, hauing one quantity of Powder, and the Range noted; I demaund whether, being charged with any other quantity of Powder, the Ranges of the
same

same Bullets, shall not alway retaine the same proportion?

M. N. I also deny that the *Ranges* shall retaine the same Proportion, for that the waight of one shot will neerer approach then the other towards the convenient length of the *Peece* and force of the other quantity of *Powder*, And therefore that aduantage will alter the proportion therein.

24.

M. D. If in a *Falcon*, for example, by experience I find two such quantities of *Powder*, as discharging the *Falcon* with the first Quantity of *Powder*, with an *Iron*, shot; and againe discharging her with the second quantity and a *Lead* shot, they Range both duely one ground: I demaund whether in a *Saker* of the same Length with the *Falcon*, Charging her first with an *Iron* Bullet, then with a *Lead* Bullet, using the same quantities of *Powder*, whether their *Ranges* shall be proportionalls? And whether doubling either quantity of *Powder*, it shall alter the proportion of the *Ranges*? Vnanswered.

M. N. I say vnto the first part of this double Question, that the *Saker* shall not make proportionall *Ranges* of ground. First, for that the *Saker* is of a higher Bore; And secondly, for that the convenient proportions of *Powder* cannot agree with those quantities (But I neuer heard of a *Saker* so short as a *Falcon* by a foot at the least.) And to the second part I say, if at the first they had beene proportionalls, yet they would alter their *Ranges* by doubling convenient proportions of either quantity of *Powder*.

25

M. D. If two *Peeces* of one Length be of such different

F 3

Quantity

No.

Quantity of Bullet, that the one being discharged with a Lead Bullet, the other with an Iron Bullet, either having Powder the waight of their Bullet, and so make equall Ranges : I demaund whether either of them discharged with halfe the waight of their Bullets in Powder shall Range alike also?

M.N. No certainly, for the halfes will bee further of, (then the whole waights were) from the Conuenient meane : Therefore their Ranges will not be alike ; for then the Iron shott will outrange the Leaden.

26.

Not alwayes.

M.D. If two Peeces be of one Length, but of seuerall quantity of Bullet, and yet of one kinde of Mettall or substance, and discharged with the waight of the Bullet, in one kinde of Powder : I demaund whether they shall not Range one ground, being equally Mounted?

M.N. Not at any time, if the Peece of the lower Bore haue her due length : For then shee will ouer-Range the other of the greater Bore.

27.

Vnanswered.

M.D. If there be once found by experience in some one Peece such a perfection of a Cannon, as whether yee make him longer or shorter, hee shall Shoot lesse ground, hauing alwaies the waight of his Bullet, of one kinde of Powder to his Charge : I demaund whether if another Peece whose Cannon or Hollow Cylinder is in proportion like to the same, although greater in Quantity, shall not be of the same perfection?

M.N. No, vnlesse there bee a due conuenient Fortification and length of her Cylinder proportionall vnto the height of her Bore waight of her shott
and

and Force of the Powder of her conuenient Charge. But with those conditions I say, yes, it shall bee of like perfection.

28.

M. D. *If two Peeces hauing their Hollow Cylinders Vnanswered: similes or proportionall be discharged with the waight of their Bullets in Powder at like Randon, I demaund the proportion of their Ranges; the quantity of their Cylinders knowne?*

M. N. If the range of one shott be truly knowne of either peece, made (with like loadings and accidents) either vpon the leuell or any Mount assigned, then by my Expositions before set downe vnder M. Digges his three last *Definitions* (preceding his *Theoremes*) both the said *Ranges* may be found, as is well demonstrated by *Nicholas Tartaglia* in his seauenth Proposition of his second Booke intituled his *Noua Scientia*. Where he saith, *That euery Range or violent motion of a body equally heavy (as round shot is) bee it great or small, equally mounted aboue the Horizon, or equally oblique or paralell to the plane of the Horizon, they will make their Ranges like, and consequently be proportionall in their distances.*

29.

M. D. *Of any two Peeces presented, to know which shall shoot furthest, being both Charged with the waight of their Bullet in Powder, The force of the Powder being first in some one approued?*

M. N. If the Length of the *Cylinders*, bee in like proportions conuenient to their Bores Height and Charge, then the longer the Peece the farther shee shooteth. Otherwise the *Cylinder* (may by being too long

C

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 long) make the longest shoote shortest.

30.

Vnanswered. M. D. *Any two Peeces proponed, how to charge them with such quantity of Powder as they may both at like Randons, Range like ground.*

M. N. There in the Force of the said quantities of Powder, compared with the length of the Concaue *Cylinder*, and waight of the Shott, and all other circumstances must be considered: and so applied that th. Peece that would shoote farthest must be proportionally abated of her allowance of Powder, as that which would shoote shortest is the more weake.

31.

Vnanswered. M. D. *Hauing proued any Peece at his utmost Randon with any one kinde of Powder, to know how to diminish the Proportion of Powder from time to time in such proportion, as the Peece keeping that Randon, shall shoote any part you will assigne?*

M. N. Hauing by my answer to Master Digges his 11. Question, or otherwise found how much *Petre* is in that quantity of powder proued, and deminished it according to the force you desire to lessen; and hauing by my Expositions vpon M. Digges three last Definitions (preceding his *Theoremes*) found the Ranges, you may finde Leading markes: But proportionall proofes manually acted, exceedeth Art herein, by reason of vnseene accidents.

32.

Not equall
 but proportionall.

M. D. *whether the right Line of the utmost Randon be equall to the right Line of the Leuell Range, Or whether in all Peeces they retaine proportion?*

M. N.

M. N. The Leuell straite Line or course of a shott Explained in the 11. Definition contained in the 5. page, is as the best Randon, as 1. to 5. as Tartaglia and others haue demonstrated agreeing neerely with experience; Therefore they cannot bee equalls, but they are alwayes proportionalls in all Peeces.

M. D. Whether the right Line of the utmost Range bee lesse then the right Line of 90. Grades of Randon?

Yes.

M. N. No, for the right Range or straite Line of the Bullets course at the mounting of any Peece to 90. degrees, is there longest, and is directly perpendicular to the Horizon.

M. D. Whether the right Line of the utmost Range be a Meane-proportionall betweene the right line of the Leuell Range, and the right Line of the verticall Range, viz. mounted to 90. Grades?

Yes.

M. N. No, by the next answer following, but every straite Line of any Peece, for each Mount is proportionall to the straite Line of any other Peece like loaded and mounted, compared with any Ranges of equall Mounts for those Peeces giuen.

M. D. Whether the right Line of the utmost Randon, be not rather a meane proportionall, betweene the Leuell right Range, and the grade of Randon that Rangeth the ground of the Leuell Range?

Yes.

M. N. Yes, especially in a Calme, and that meane proportionall will be found to bee somewhat aboue 40. degrees by the 19. Definition and the Exposition thereof.

G

M. D. Whether,

Yes in a
Calme.

36.
M.D. whether the Right lines made by any two Peeces discharged, be not proportionall to the Ranges of their Bullets at the same Randon?

M.N. Yes, by the 20. and 21. Definitions and Expositions hereof: And as it is well demonstrated by Tartaglia in his *Nova Scientia*, and his *Coloquies*.

Not answered.

37.
M.D. whether the right Lines made by any two Peeces at any Randon, be not proportionals with their utmost Ranges?

M.N. Yes doubtlesse, neuerthelesse the 23. of M. Digges his said Theoremes concerning great Ordinance herein incerted; And as it will appeare by my two Explanations and Tables following his 20. and 21. Definitions aforesaid.

No.

38.
M.D. whether the Utmost Randon, (I meane to make the utmost Range) be alwaies one, whether the ground be leuell or ascending?

M.N. No, it cannot be so, for that the ascending ground doth sooner meet with the way of the shot, then the Leuell, and the Leuell sooner then the descending plane.

No.

39.
M.D. whether the Bullet end his Range with a Lyne, not sensibly different from a strait Line; As it doth begin his Circuit?

M.N. Yes, vnder 60. degrees of Mount, but about 70. 80. and vnto 90. it endeth in a perpendicular right Line, which is a right and strait Line.

M.D. whe-

40.

M. D. whether all Peeces at one Randon discharged, as they make one Angle at the beginning of their course, doe make one Angle at the end of their Race? Not answered.

M. N. Yes, they doe as in Tartagliaes Nova Scientia is demonstrated, vpon all like planes, and meeting with like Accidents.

41.

M. D. whether the Angle at the end of the Circuit made with the Bulles bee equall with the Angle of Randon?

No.

M. N. No, it doth not; for it is alwaies greater, except at the Mount of 90. degrees.

42.

M. D. whether the upper part of the Circuit made with the Bullet be a proportion of a Circle as Tartaglia supposeth?

No.

M. N. No, for it is a Mixt, Curved or Helisphericall Line or Circuit, proper to the degree of mounting.

43.

M. D. If a Falcon of three Inches Bullet waigh 700. pound, I demand how much a Cannon of eight inches will waigh, that is able to receive his proportionall Charge to that Cannon?

M. N. This cannot bee answered by the simple Rule of proportion, because waight is not appertaining to Lines nor to Superficies, but vnto Solid Bodies. And also you may note that although M. Digges here compareth the Falcon which is at least 30. of the Diametres of her Bore in Length, and Fortefied with Mettall to endure the waight of her shott in powder, with the Cannon that is but 18. or 24. Diametres of her Bore in length, and no better fortetied then to

endure $\frac{7}{8}$. of her shotts waight in Powder: But comparing the *Falcon* with a *Demi-Culvering* that is of the same kinde and Fortification, whose shott waigheth 10. pound, the Question is Answered thus: for

Example.

Unanswered. The Cube of three (the inches of the height of the Falcons Bore) is 27. & the Cube of 4 $\frac{1}{2}$ (the inches of the Demi-Culuerings Bore) is 91. (*scilicet*) Now say by the Rule of three, if 27. giue 91. what shall 700. giue? And so hauing accordingly Multiplied the third number by the second, and diuided the product by the first, you shall haue in the Quotient 2359. pound $\frac{7}{8}$. for the waight of the said *Demi-Culvering* sought.

44.
M.D. If a *Falcon* of 3. inches Bullet require 3. pound of Powder for his charge, I demand how much Powder will charge a *Cannon* of 8. inches Bullet?

M.N. Because this Question is of seuerall kindes of Ordinance, as is said in the last precedent Answer, I haue also applyed this Answer, and the *Example* to the said *Demi-Culvering* thus: for

Example.

Multiply 91. the Cube of 4 $\frac{1}{2}$. by 3. $\frac{1}{2}$. the charge of the *Falcon*, and the product will be 273. which I diuide by 27. the Cube of 3. (the Diametre of the *Falcon*) And the Quotient I finde to be 10. pound and $\frac{1}{2}$. for the Powder of the due charge for the said *Demi-Culvering* sought.

Not answered.

M.D. If the *Falcon* that carryeth Point Blank 150. paces, and at the utmost Randon 1300. paces: I demand how

how farre a Culvering at his utmost Randon will reach, that at Poynt-blanke, or Leuell rangeth 250. paces?

M. N. Say by the Rule of 3 if 150. giue 1500. what shall 250. giue? answer, 2166. paces, and $\frac{1}{2}$. for the utmost range of the *Culvering* sought.

M. D. And thus by obseruations vsed in one Peece, by this *Art of Proportion*, a man may discover the Force of all Peeces.

M. N. The Gunner may know by her leuell right Range how farre his Peece will conuey her shotte at any Elevation mounted: If he multiply the number of Paces shee carrieth in a strait line, (shee lying leuell) by 11. and diuide the product by 50. the Quotient will be the greatest digression, which it maketh at the first degree more then at the Leuell. But all other degrees proceed alwaies deminishing vnto the utmost Randon: and to know how they deminish, take the number of degrees from one to 41. the best of the Randon, and that will be 40. by which diuiding the said number of the former Quotient; This Quotient will be the number of Paces, which shall decrease from degree to degree, from the first vnto the utmost Randon. As for Example: For the *Culvering* that shoot 250. paces leuell in a strait Line; I doe multiply that, by 11. and it produceth 2750. which I diuide by 50. and the Quotient will bee 50. paces; which it shooteth at the first degree more then at the leuell; which 50. paces, diuided againe by 40. (the degrees betweene the first degree and the utmost Randon) & this Quotient will be 1. pace and $\frac{1}{4}$. which I take from 350. namely from the 250. & the 50. increased at the first, and also the 50. to be increased for the

second digression, it leaueth 348. paces $\frac{1}{2}$. for the Range of the second degree, vnto which adde 48. paces $\frac{1}{2}$. abating the one pace; $\frac{1}{2}$. and there will bee 195. $\frac{1}{2}$. for the paces of the Range of the third degree, and so proceed.

*Certaine Erronious Positions and Grounds published
by professors of this Art of Great Artillery,
noted by Mr. Digges.*

THat in all Peeces of Ordinance mounted aboue the vtmost Randon, the Bullet is violently carried in a right Line to his vtmost distance from the Earth, and then falleth perpendicularly downe to the Horizon.

2. That all Peeces of one Bullet being charged with one quantity of the same Powder, and discharged at one *Randon*, shall make their *Ranges* proportionall to the Length of their Peeces.

3. That if you Charge any one Peece, with seuerall quantities of one kinde of Powder (the Peece being discharged two seuerall times, at one *Randon*, and with the same Bullet, shall make different *Ranges* proportionall to the waight or quantity of the powder.

4. The fourth and chiefe of all the rest, is the Grade of vtmost *Randon*; For most Writers that euer I read, agree in this, that the mount of 45. grades aboue the Horizontall plane, should make there the vtmost Range.

5. That euery degree of *Randon* doth equally encrease the *Range* in any one Peece, from the Zenith to

45. their *Tropike* grade, and so in decreasing likewise, and that proportionally in all peeces more or lesse according to their Force.

6. That in all sorts of Peeces, the difference of their vtmost Ranges should be in proportion answerable to the waight of their Bullets and Charges of Powder.

Other Erronious Positions published concerning Ordinance; Noted by Robert Norton.

1. **T**hat when a Peece is to shoot at a marke aboue the Leuell, being within distance of the right Range, then it by the vertue of the Fire that ascendeth ouer-shooteth the Mark. And that therefore to remedy it, the Peece must bee so much imbased, vntill a Plum line at the Cornice let Sior. Collado. fall, will not enter but touch the lower side of the fol. 61. mouth of the Peece.

The same Author there affirmeth Folio 60. that if any Peece be to shoote from aboue downwards to a marke vnder the Leuell, and the Peeces Metall directed to the marke, that then the Peece must be so much Eleuated more, as may equall the Angle, that the Peeces flatt of her mouth maketh with a Plum line applied thereunto to equall the Naturall defect caused by the ponderous descending of the shott in her mixt motion or crooked Range.

Mr. Smith hath published in his *Art of Gunnery*, page 35. that if a *Saker* will conuey her Bullet at *Point blanke* 200. paces, and at the best of the *Random* 900. paces, that then that *Cannon* will shoote 1620. paces

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paces at the best Randon that carryeth at *Point-blank* 360. paces, which is very erroneous, for that at the best of the Randon the shott rangeth rather 10. times as much as at the Leuell Range.

And also page 39. he affirmeth, that if a *Calvering* be shotte off with $\frac{1}{2}$. of the waight thereof, and then with the whole waight of her shott in Powder, that then the second shott shall bee neere $\frac{1}{2}$. further then the first.

And page 46. that a Cannon that shooteth 1440. paces at 45. degrees, will for every degree of lesse Mount, abate 32. paces in her Range.

And page 47. he saith that a Cannon that shooteth at her best Randon 1440. paces, will shoot at 30. degrees, but 960. paces, whereas in that case shee will conuey her shott being like loden and mounted about 1269. paces.

And page 49. he saith, that if you abate the Leuell Range of a Peece from the vtmost Range thereof, and diuide the remainder by 45. degrees, then the Quotient will shew you how farre the shott is carryed at every degree.

Or by diuiding the same number by so many degrees, as you would eleuate your Peece at, The Quotient hee saith doth shew how farre the Bullet doth range beyood *Point-blank*, and that thereby you may make a Table of Randons.

But he either forgetting, or I thinke rather not knowing that the best Randon is but little aboue 40. degrees Eleuation, or that the Peece shooteth thereat about 10. times as much as the Leuell Range, Or that the Ranges deminish from 1. to the best Range, and increase from the best to 90. degrees Eleuation; It hath made him publish these and many other Erronious positions.

FINIS.

3.4
STC 18676 R. Norton, Of the Art of
Great Artillery, 1624

Before it was rebound separately (by Robert Lunow) this pamphlet was unbound but sewn with Norton's Gunners Dialogue, the two having once been the first two items in a thick 18th-century volume. While the work was in sheets I found the collation to be as below:

A-G⁴.

All pairs of leaves were normally conjugate.

27 Feb 1961

18676